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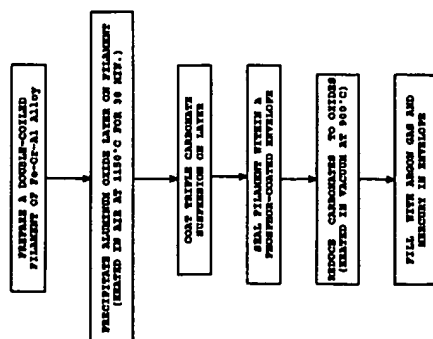
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(54) Method of fabricating an electrode for a discharge lamp and the electrode formed thereby.

(57) An electrode for a discharge lamp is formed, which has an improved adhesion between the emitter material and the filament. A filament made of an Fe-Cr-Al alloy is placed in a heated oxidising environment to precipitate an aluminium oxide layer uniformly on its surface. The thus precipitated aluminium oxide layer has good adhesion with the filament without flaking. The aluminium oxide layer is coated with triple carbonates consisting of barium carbonate, calcium carbonate and strontium carbonate, so that a carbonate coated filament is obtained. The coated filament is then heated in vacuum to reduce the carbonates to their alkaline earth oxides of the emitter material, and also to form a complex oxide consisting of the aluminium oxide and the alkaline earth oxides. Adhesion between the emitter material and the aluminium oxide layer is improved by the formation of the complex oxide, so that the lamp life of the discharge lamp is remarkably increased. On the other hand, since the Fe-Cr-Al alloy has a much higher specific resistance value than tungsten, the discharge lamp using a filament of the Fe-Cr-Al alloy can be operated by a small current, which in turn enables a lamp driving circuit that is reduced in size and weight.

FIG. 1



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## TECHNICAL FIELD

The present invention is directed to a method of fabricating an electrode for a discharge lamp which comprises precipitating an aluminum oxide layer in a surface of a Fe-Cr-Al alloy and forming an emitter material on the aluminum oxide layer, and the electrode formed thereby.

## BACKGROUND ART

An electrode for a discharge lamp such as a fluorescent lamp is generally fabricated by the following method. That is, a tungsten filament is coated with a carbonate suspension of alkaline earth metals which consist of barium, calcium and strontium, so that a carbonate coated filament is obtained. And then, the carbonate coated filament is heated in vacuum to reduce the carbonates to their oxides. Since the oxides have relatively low work functions, they are able to supply thermo electrons with a low voltage. Therefore, the oxides are utilized as an emitter material for the discharge lamp. By the way, it is known that a lamp life of the discharge lamp depends on a depletion of the emitter material during lamp operation. That is, the emitter material is evaporated from thus fabricated electrode by an ion bombardment of a fill gas which is filled in an envelope of the discharge lamp, and also by heating the electrode at a high temperature of about 1000 °C to operate the lamp. As thus evaporated emitter material attaches on an inner surface of the envelope, a light output of the lamp is depreciated. Therefore, it is requested for increasing the lamp life to improve adhesion between the emitter material and a filament. On the other hand, it is desired that a lamp driving circuit for the discharge lamp is reduced in size and weight. In case of using the tungsten filament to the discharge lamp, an electrical conductivity of the tungsten filament remarkably increases as a temperature of the tungsten filament is higher. The tungsten filament has a low specific resistance at a room temperature, for example,  $5.49\mu\Omega\text{cm}$  at 20 °C. The room temperature mentioned in this specification is in a range of 0 °C to 40 °C. A large amount of current flows through the tungsten filament as a rush current immediately after a lamp voltage is applied to operate the lamp. However, when the tungsten filament is heated at about 1000 °C during the lamp operation, the specific resistance of the tungsten filament increases to  $24.93\mu\Omega\text{cm}$ . As the temperature of the tungsten filament is higher, an amount of current flowing through the tungsten filament decreases. Therefore, the lamp driving circuit corresponding to a large difference of specific resistances of the filament between at the room temperature and the high temperature is requested for the discharge lamp. In addition, as the tungsten filament has a low electrical resistance value at the high temperature, as described above, a relatively large amount of current is required to keep the tungsten filament to the high temperature during the lamp operation. Therefore, the lamp driving circuit corresponding to the large amount of current also needs for the discharge lamp. In order to enable reduction in size and weight of the lamp driving circuit for the discharge lamp, it is desired that a filament material has a small difference of specific resistances of the filament between the room temperature and the high temperature, and also a higher specific resistance value at the high temperature compared with the tungsten filament. The discharge lamp using the filament material can be operated by a small current, which in turn enables the lamp driving circuit to be reduced in size and weight. For example, a heater wire such as a Fe-Cr-Al alloy and Ni-Cr alloy has a small difference of the specific resistances between at the room temperature and the high temperature, and a relatively high specific resistance value at the high temperature. However, when the heater wire is used as the filament material of the lamp, there is a possibility of the filament deforming or melting during the lamp operation because the heater wire has a lower melting point than tungsten.

Japanese Patent Early Publication [KOKAI] No. 54-121660 describes about a cathode for Braun tube. An interface layer which is composed of alumina and barium oxide or silica and barium oxide is formed between the alkaline earth oxides of the emitter material and a cathode substrate. The cathode substrate consists of 20 to 30 wt% of tungsten, 0.01 to 5 wt% of zirconium as a reducer and the balance of nickel. An emission of thermo electrons from the cathode is stably maintained for a long time period by controlling a depletion rate of the reducer, so that a life of the braun tube is increased. The depletion rate of the reducer is controlled by the interface layer.

U.S. Patent No. 4,836,816 describes about a method of treating a tungsten cathode for increasing a lamp life of the fluorescent lamp. The tungsten cathode is coated with a triple carbonate suspension, and then is placed in a heated oxidizing environment in order to form a diffuse coating consisting of the triple carbonates and tungsten oxide. The triple carbonates consist of barium carbonate, calcium carbonate and strontium carbonate. Subsequently, a cathode activation process is performed to the tungsten cathode with the diffuse coating. That is, the triple carbonates are reduced to their respective oxides by passing heater current through the tungsten cathode. The diffuse coating enhances the chances of forming barium

tungstate during the cathode activation process. As a result, the lamp life of the fluorescent lamp is increased and the amount of phosphor darkening is reduced. Although the above-described methods may increase the life of the fluorescent lamp or the braun tube to some degree, it is desirable to have more improved alternative methods.

5 The present invention relates to a method of fabricating an electrode for a discharge lamp having an increased lamp life. The Fe-Cr-Al alloy having a small difference of specific resistances between at a room temperature and a high temperature of about 1000 °C, and a relatively high specific resistance value at the high temperature is utilized as an electrode substrate. The discharge lamp using the alloy can be operated by a small current, which in turn enables a lamp driving circuit to be reduced in size and weight. The Fe-Cr-  
10 Al alloy is placed in a heated oxidizing environment to precipitate an aluminum oxide layer uniformly in the surface thereof. Thus precipitated aluminum oxide layer has good adhesion with the alloy without flaking thereof as compared with the aluminum oxide layer formed by another methods such as, for example, a sputtering method and an oxide plating method. The emitter material is then formed on the aluminum oxide layer. The emitter material includes at least one selected from alkaline earth oxides consisting of barium  
15 oxide, strontium oxide and calcium oxide. Adhesion between the emitter material and the alloy is improved by the formation of the aluminum oxide layer. Therefore, an evaporation of the emitter material from thus fabricated electrode during lamp operation is prevented, so that the lamp life of the discharge lamp is increased.

It is, therefore, a primary object of the present invention to provide a method of fabricating an electrode  
20 for a discharge lamp which comprises precipitating an aluminum oxide layer uniformly in a surface of Fe-Cr-Al alloy and forming an emitter material on the aluminum oxide layer, and the electrode formed thereby.

In the method of fabricating the electrode for the discharge lamp of the present invention, it is preferred that the Fe-Cr-Al alloy consists of 10 to 30 wt% of Cr, 1 to 10 wt% of Al and the balance of Fe. On the other hand, it is also preferred that a thickness of the aluminum oxide layer is 0.1 μm to 5 μm to improve  
25 adhesion between the emitter material and the alloy.

The method of fabricating the electrode for the discharge lamp and the electrode formed thereby will be detailed hereinafter.

#### DETAILED DESCRIPTION OF THE INVENTION

30 A Fe-Cr-Al alloy wire is used to form a filament for a discharge lamp. Of course, in the present invention, a shape of the Fe-Cr-Al alloy is not limited to the filament. A specific resistance of the Fe-Cr-Al alloy is about 150 μΩcm at a high temperature of about 1000 °C. The specific resistance of the alloy is much higher than that of tungsten at about 1000 °C which is about 35 μΩcm. Therefore, the filament of the  
35 alloy is kept to the high temperature with a small amount of current during lamp operation. The Fe-Cr-Al alloy also has a small difference of specific resistances between at a room temperature and the high temperature, that is, the specific resistance of the alloy at about 1000 °C is only about 1.036 times as large as that at 20 °C. Therefore, immediately after a lamp voltage has been applied to operate the lamp, the discharge lamp using the filament of the alloy can be operated by a small current, which in turn enables a  
40 lamp driving circuit to be reduced in size and weight. However, the alloy wire was not used as the filament of the lamp in the past. Because there is a possibility of the alloy wire deforming or melting during lamp operation. And also, the alloy has a relatively high vapor pressure in a low pressure atmosphere. Therefore, the alloy is readily evaporated during the lamp operation. Thus evaporated alloy attaches on an inner surface of an envelope of the lamp. so that a light output of the lamp is depreciated. In the present  
45 invention, for obviating the disadvantages of the alloy wire, an aluminum oxide layer is precipitated in a surface of the alloy wire as described below. The aluminum oxide layer has capable of preventing a deformation of the alloy wire and an evaporation of the alloy wire during the lamp operation. Consequently, the alloy wire is able to use as the filament.

The discharge lamp using an electrode of the present invention is fabricated in accordance with the  
50 following method. That is, the alloy wire is placed in a heated oxidizing environment, for example, in a heated air, to precipitate the aluminum oxide layer uniformly in the surface of the alloy wire. Thus precipitated aluminum oxide layer has good adhesion with the alloy wire as compared with the aluminum oxide layer formed by another methods, for example, a sputtering method and an oxide plating method. Although not fully understood, it is believed that the aluminum oxide layer precipitates in the surface of the  
55 alloy wire so as to minimize a thermal stress resulting from a difference between thermal expansion coefficients of the aluminum oxide and the alloy. It is preferred that this heat treatment is performed at about 700 °C to 1300 °C for 5 minutes to 15 hours. Subsequently, an emitter material is formed on the aluminum oxide layer. For example, an alkaline earth carbonate suspension is painted, dipped or otherwise

coated on the aluminum oxide layer, so that a carbonate coated alloy wire is obtained. The carbonate suspension usually comprises barium carbonate, calcium carbonate and strontium carbonate. After the carbonate coated alloy wire is sealed within a phosphor-coated envelope, the envelope is evacuated of air. And then, an activation treatment of the carbonate coated alloy wire is performed in the envelope. That is to say, the activation treatment comprises heating the coated alloy wire in vacuum to reduce the alkaline earth carbonates to their oxides, and also to form a complex oxide consisting of the aluminum oxide and the alkaline earth oxides. The alkaline earth oxides is used as the emitter material for supplying thermo electrons. The emitter material is tightly bonded with the aluminum oxide layer through the complex oxide formed at an interface between the alkaline earth oxides and the aluminum oxide. And also, it is believed that as the aluminum oxide diffuses into grain boundaries of the emitter material during the lamp operation, the complex oxide is formed in the grain boundaries, so that adhesion between grains of the emitter material is improved. Therefore, an evaporation of the emitter material during the lamp operation is remarkably prevented. The activation treatment is performed at 800 °C to 1300 °C for a short time period. After the activation treatment, the envelope is filled with a conventional fill material including mercury and a rare gas or mixtures of rare gases such as neon and argon. By the way, it is desired that the Fe-Cr-Al alloy wire consists of 10 to 30 wt% of Cr, 1 to 10 wt% of Al and the balance of Fe. For example, KANTHAL heater wire (trade name of a heater wire manufactured by KANTHAL AB), or PYROMAX heater wire (trade name of a heater wire manufactured by RIKEN corporation), is used as the alloy wire. When an Al content in the alloy wire is less than 1 wt%, it is difficult to precipitate the aluminum oxide layer uniformly in the alloy wire. When the Al content is more than 10 wt%, a machinability of the alloy wire is lowered, so that it is so difficult to make the filament thereof. When a Cr content in the alloy wire is less than 10 wt%, it is so difficult to precipitate the aluminum oxide layer uniformly in the alloy wire. Because a matrix phase of the alloy is an austenite phase, and the austenite phase forms a solid solution with aluminum atoms in the alloy. When the Cr content is more than 30 wt%, the machinability of the alloy wire is lowered. It is also preferred that the difference of specific resistances of the alloy between at the room temperature and 1000 °C is less than 10% of the specific resistance of the alloy at the room temperature. On the other hand, It is desired that a thickness of the aluminum oxide layer is in a range of 0.1 μm to 5 μm. When the thickness is more than 5 μm, the electrode can not efficiently supply thermo electrons. When the thickness is less than 0.1 μm, adhesion between the emitter material and the aluminum oxide layer is not improved.

The discharge lamp using the electrode fabricated in accordance with the present invention, as described above, has the following properties, that is,

[1]: The discharge lamp has a long lamp life,

[2]: The discharge lamp has capable of keeping the electrode to the high temperature with a small amount of current during lamp operation.

Further details of the present invention are described in the following Example. However, the Example is illustrative of the invention, but is not to be construed as to limiting the scope thereof in any manner.

#### BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is an flow chart illustrating a method of fabricating a fluorescence lamp in accordance with the principles of the present invention;

#### Example

A fluorescence lamp of Example was fabricated in accordance with the following method, as shown in FIG. 1. A Fe-Cr-Al alloy wire having a composition of 22 wt% of Cr, 4.8 wt% of Al and the balance of Fe was used to form a double-coiled filament. A diameter of the alloy wire was 50 μm. A diameter of a first coil of the double-coiled filament was 300 μm. A diameter of a second coil of the double-coiled filament was 500 μm. A total length of the double-coiled filament is 20mm. A specific resistance of the alloy at 1000 °C is only 1.036 times as large as that of the alloy at 20 °C which is about 145 μΩcm. The filament was heated in an air at 1150 °C for 30min to precipitate an aluminum oxide layer uniformly in a surface thereof. Subsequently, a triple carbonate suspension comprising barium carbonate(BaCO<sub>3</sub>), calcium carbonate-(CaCO<sub>3</sub>) and strontium carbonate(SrCO<sub>3</sub>), was coated on the aluminum oxide layer, so that a carbonate coated filament was obtained. The coated filament was sealed within a phosphor-coated envelope of the fluorescence lamp of 20W, and then the envelope was evacuated of air. An activation treatment of the coated filament was performed in thus evacuated envelope. That is, the coated filament was heated in vacuum at 900 °C by passage of current therethrough to reduce the triple carbonates to their alkaline earth oxides, and also to form a complex oxide consisting of the aluminum oxide and the alkaline earth oxides.

The alkaline earth oxides functions as an emitter material for supplying thermo electrons. Adhesion between the emitter material and the aluminum oxide layer is improved by the formation of the complex oxide. After the activation treatment, the envelope was filled with argon and mercury. As a result, the fluorescence lamp of Example was fabricated.

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#### Comparative Example

A fluorescence lamp of Comparative Example was fabricated by the following method. A tungsten wire was used in stead of the Fe-Cr-Al alloy wire. A specific resistance of the tungsten is  $34.8\mu\Omega\text{cm}$  at  $1000^\circ\text{C}$ .  
 10 A double-coiled tungsten filament was formed so as to have the same shape as Example. The triple carbonate suspension was coated on the tungsten filament, so that a carbonate coated tungsten filament was obtained. The coated tungsten filament was sealed within the envelope of the fluorescence lamp of 20W, and then the envelope was evacuated of air. An activation treatment of the coated tungsten filament was performed in thus evacuated envelope. That is, the coated tungsten filament was heated in vacuum at  
 15  $900^\circ\text{C}$  by passage of current therethrough to reduce the triple carbonates to their alkaline earth oxides. After the activation treatment, the envelope was filled with argon and mercury. As a result, the fluorescence lamp of Comparative Example was fabricated.

The fluorescence lamps of Example and Comparative Example were examined with respect to the following factors, that is,

- 20 (1): A **rush current** flowing through the filament immediately after a lamp voltage is applied to operate the lamp,  
 (2): A **lamp life** in case that the lamp is continuously operated with 2 amperes of a discharge current.

As shown in TABLE. 1, the lamp of Example has a smaller rush current than that of Comparative Example. Therefore, the discharge lamp of Example can be operated by a smaller current compared with  
 25 the lamp of Comparative Example, which in turn enables a lamp driving circuit to be reduced in size and weight. On the other hand, the lamp life of Example is more than two times as long as that of Comparative Example. This result indicates that the lamp of Example has an improved adhesion between the emitter material and the filament, so that the lamp life is remarkably increased.

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TABLE 1

Lamp performance of fluorescence lamps of Example and Comparative Example.		
Factors	Example	Comparative Example
Rush current (A)	0.9	4.1
Lamp life (hours)	1457	638

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#### Claims

1. A method of fabricating an electrode for a discharge lamp, said method comprising the steps of:  
 preparing an electrode substrate made of an Fe-Cr-Al alloy;  
 heating said electrode substrate in an oxidising environment to form an aluminium oxide layer on  
 45 the surface of said electrode substrate; and  
 coating an emitter material on the surface of the aluminium oxide layer.
2. The method of claim 1, wherein said emitter material includes at least one of the following alkaline earth oxides: barium oxide, strontium oxide, calcium oxide.  
 50
3. A method of manufacturing a fluorescence lamp comprising the step of:  
 preparing a filament made of an Fe-Cr-Al alloy;  
 heating said filament in an oxidising environment to form an aluminium oxide layer on the surface  
 of said filament;  
 55 coating the surface of said aluminium oxide layer with at least one carbonate;  
 sealing said filament with said aluminium oxide layer and said carbonate within a phosphor-coated envelope;  
 reducing said carbonate to its oxide by passing current through said filament;

evacuating said envelope; and  
filling rare gas and mercury in said envelope.

- 5       4. The method of claim 3, wherein said carbonate is barium carbonate and/or strontium carbonate and/or calcium carbonate.
5. The method of claim 4, wherein all three of these carbonates are coated on said aluminium oxide layer.
- 10       6. The method of any one of claims 1 to 5, wherein said Fe-Cr-Al alloy consists of 10 to 30 wt% of Cr and 1 to 10 wt% of Al, the balance being Fe.
7. The method of any one of claims 1 to 6, wherein the thickness of said aluminium oxide layer is in a range 0.1 to 5 $\mu$ m.
- 15       8. The method of any one of claims 1 to 7, wherein said electrode substrate is heated at a temperature of 700 °C to 1300 °C to form said aluminium oxide layer by precipitation.
- 20       9. The method of any one of claims 1 to 8, wherein the difference in the specific resistance of said Fe-Cr-Al alloy between at room temperature, which is in a range of 0 °C to 40 °C, and 1000 °C is less than 10%.

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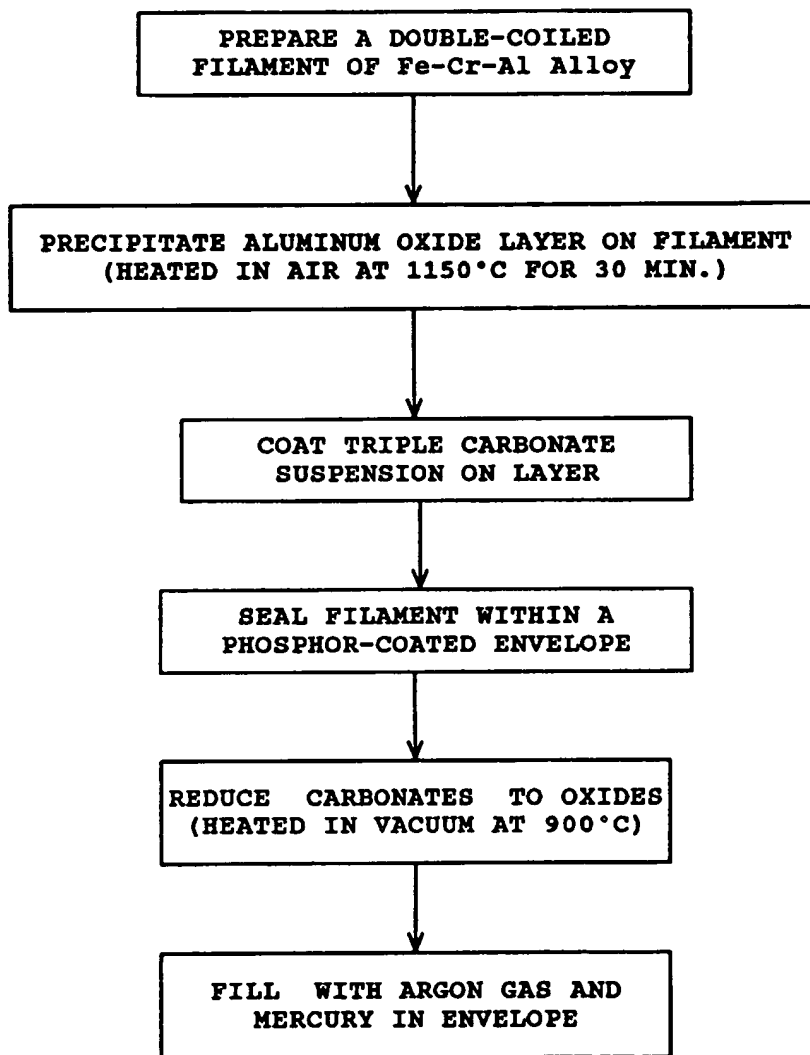
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FIG. 1





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## EUROPEAN SEARCH REPORT

Application Number

EP 92 11 9736

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	DE-A-3 819 698 (HITACHI METALS, LTD.) * abstract; claims 1,3 * * page 4, line 25 - line 37 * * page 5, line 1 - line 30 * ---	1,3,6,9	H01J9/04 H01J61/067
A	DATABASE WPI Section Ch, Week 3377, 1977 Derwent Publications Ltd., London, GB; Class L, AN 77-58702Y & JP-B-52 028 086 (TOKYO SHIBAURA ELEC LTD) 25 July 1977 * abstract * ---	1,3,6	
A,D	US-A-4 836 816 (BOUCHARD ET AL.) * abstract * ---	1-5	
D,A	PATENT ABSTRACTS OF JAPAN vol. 3, no. 143 (E-154)27 November 1979 & JP-A-54 121 660 ( HITACHI LTD ) 20 September 1979 * abstract * & DATABASE WPI Section Ch, Week 4479, 1979 Derwent Publications Ltd., London, GB; Class L, AN 79-79782B * abstract * -----	1,2	
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 09 FEBRUARY 1993	Examiner MARTIN Y VICENTE M.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	